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Filer:	Stephanie Bailey
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Actionable Site-Specific Geothermal Solutions

Salton Sea Case Study | Techno-economics | Industry Partnerships

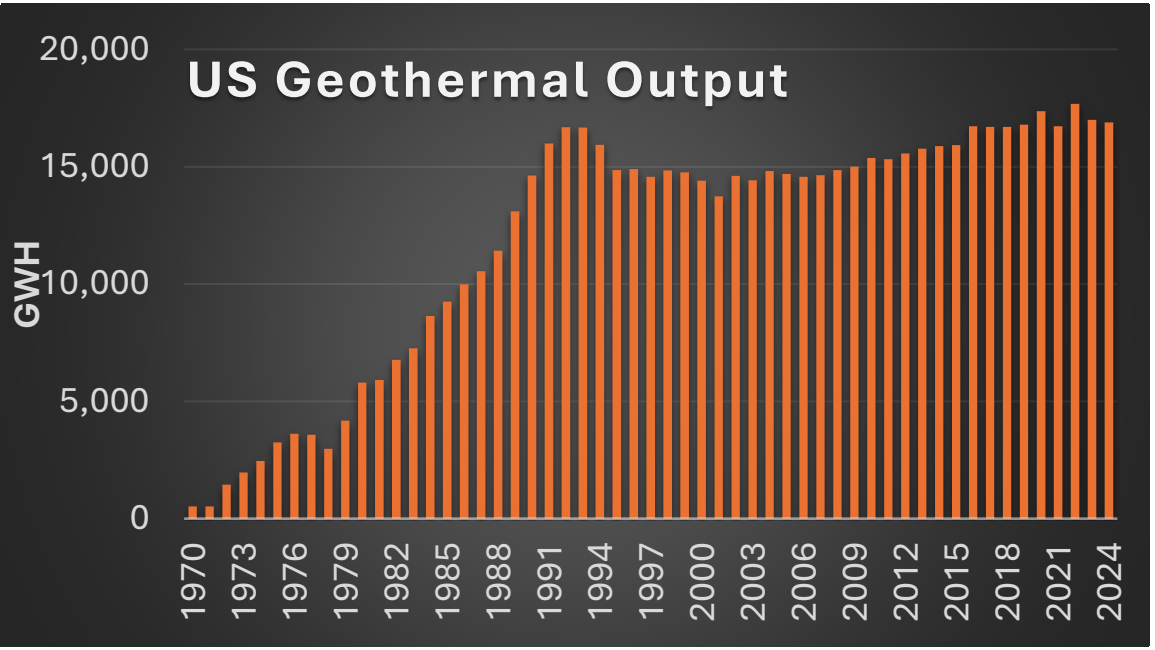
Patrick Mirick | Dave Goodman | Kyle Wilson

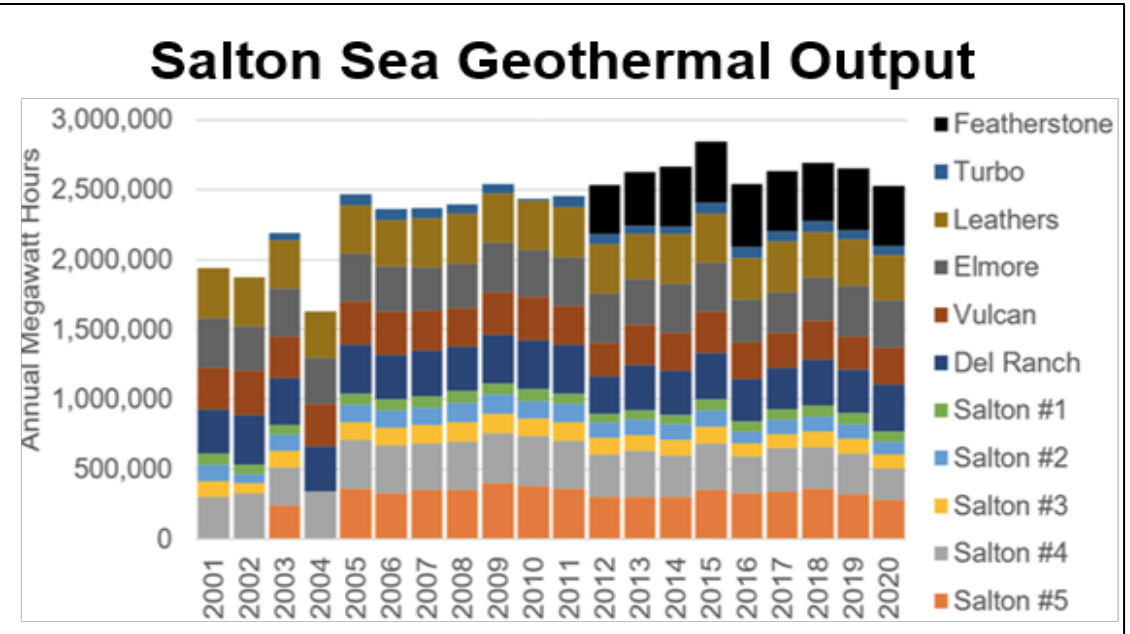
Pacific Northwest NATIONAL LABORATORY

PNNL Report funded by DOE Office of Geothermal | Comms Feature Story | TEA Modeling Tool

SECTION 1:
GEOTHERMAL PROBLEMS

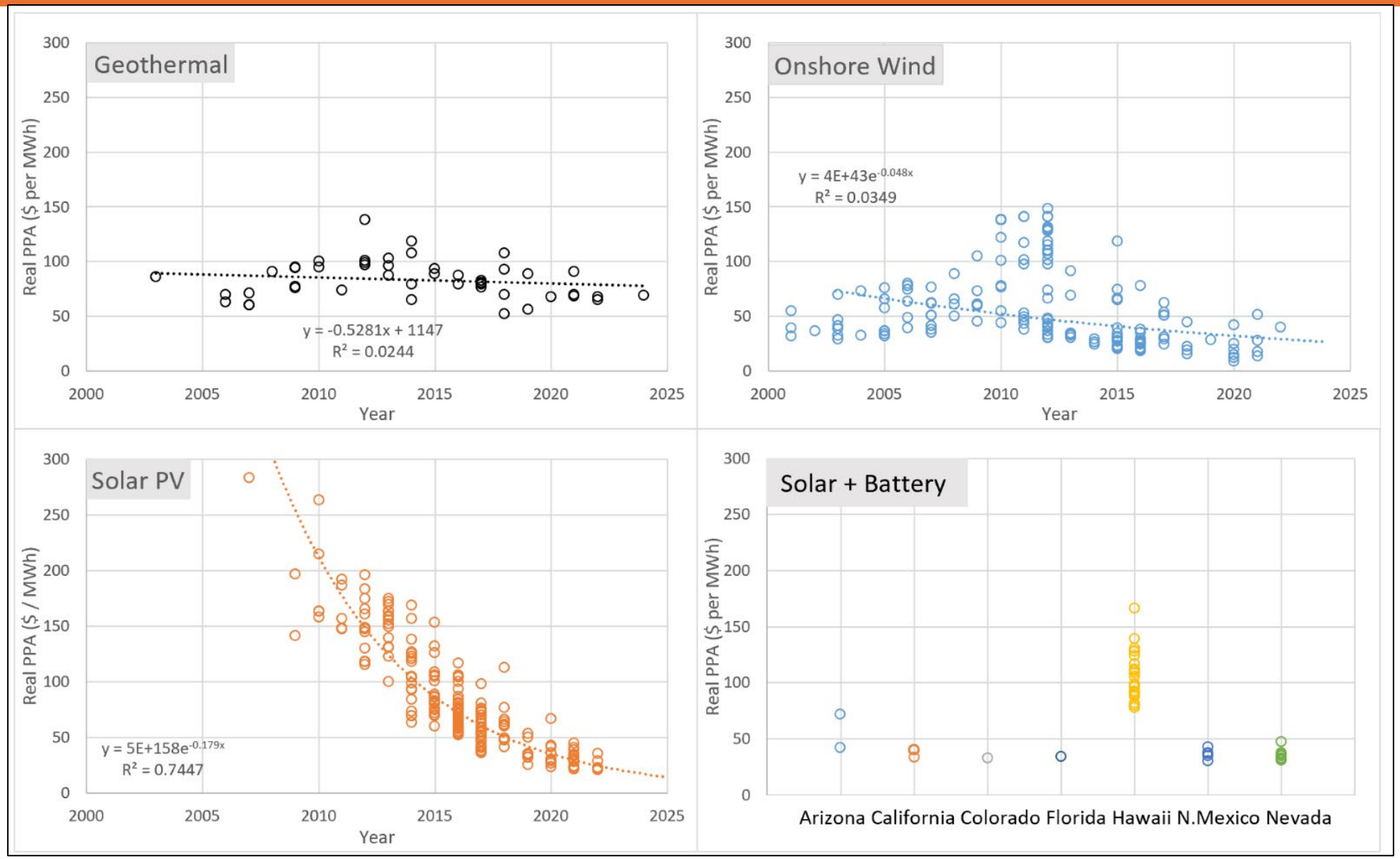
Minimal Geothermal Growth





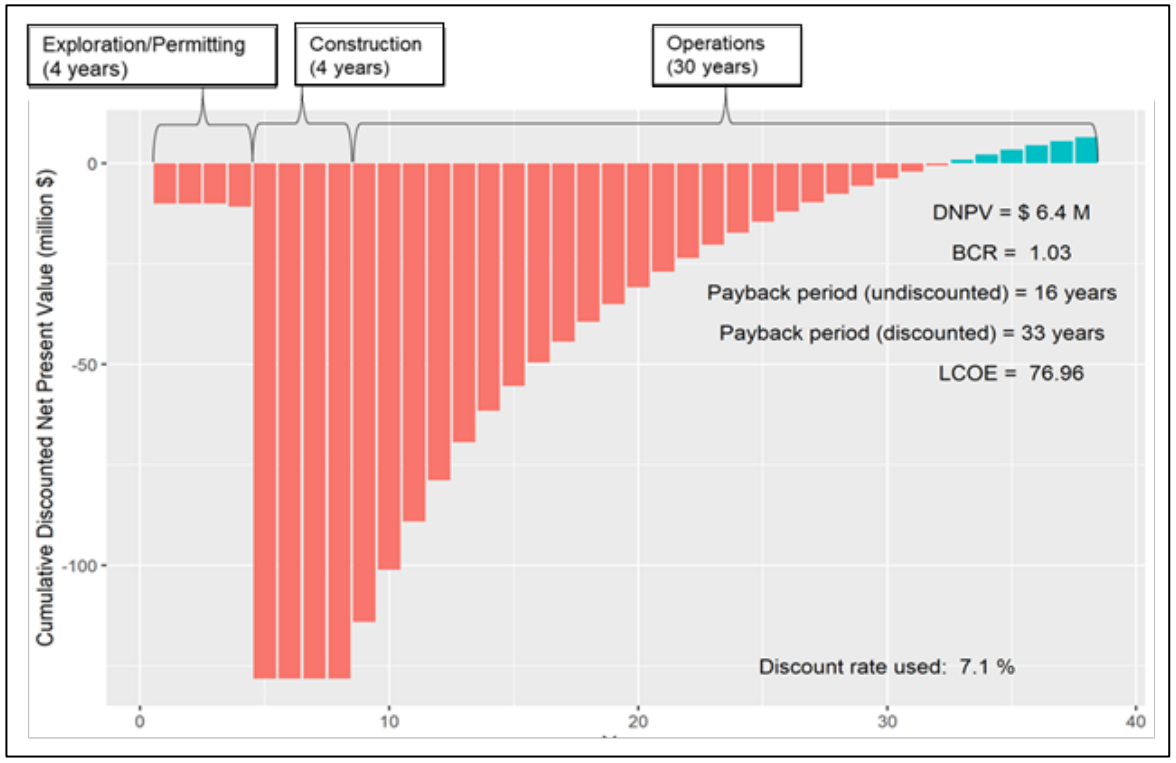
#	Geothermal Problem
1	**US output has been static since the 1980's** A: Even in prime areas like the Salton Sea
2	**Financial barriers are the main issue:** A: Payback periods are too long B: Profits are too low given risks C: Power cost is too expensive relative to competitors
3	**Numerous DOE, White House, and state policy directives to expand geothermal…**
4	**But need to evaluate actionable solutions to overcome considerable financial barriers**

"Geothermal power is too expensive relative to competitors"



Geothermal PPAs in $60-100 range vs solar + wind in $30-50 range

"Geothermal needs to be more attractive to investors"



Financial profile of a geothermal plant in the prime Salton Sea area

#	Investment issues
1	**Payback periods are too long** A: Currently at ~30-years for geothermal plants B: Need to get it down to 7-10 years
2	**Value + profits are too low given risks** A: As shown w/ the green DNPV values B: Back-up slides have a DNPV walk-through
3	**Other investment types are safer + more profitable**

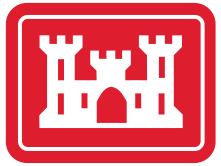
SECTION 2:
ROADMAP FOR ACTIONABLE SOLUTIONS

Steps for actionable site-specific solutions

STEP 1:	STEP 2:	STEP 3:	STEP 4:
Form a partnership w/ industry + regulators	**Identify the size of barriers + brainstorm solutions**	**Create a site-specific TEA model to evaluate proposed solutions**	**Evaluate if potential solutions can overcome financial barriers**

Forming a Salton Sea Partnership

Main Feedback	
#1	**Few new geothermal plants anywhere in past 15-20 years**
#2	**If geothermal were to thrive anywhere, it would be at Salton**
#3	**Main barrier is competition from solar**
#4	**Solar + battery is also eroding geothermal's niches:** A: 24/7 baseload power at night B: Helping w/ peak power during sunrise + sunset
#5	**Permitting times + costs are a relatively small barrier**
#6	**Lithium could be a "game changer" - but mixed levels of industry optimism since need better mineral extraction technology**



Brainstorming potential solutions

There are many potential solutions - but can they overcome the financial barriers?

Economic + Regulatory Solutions

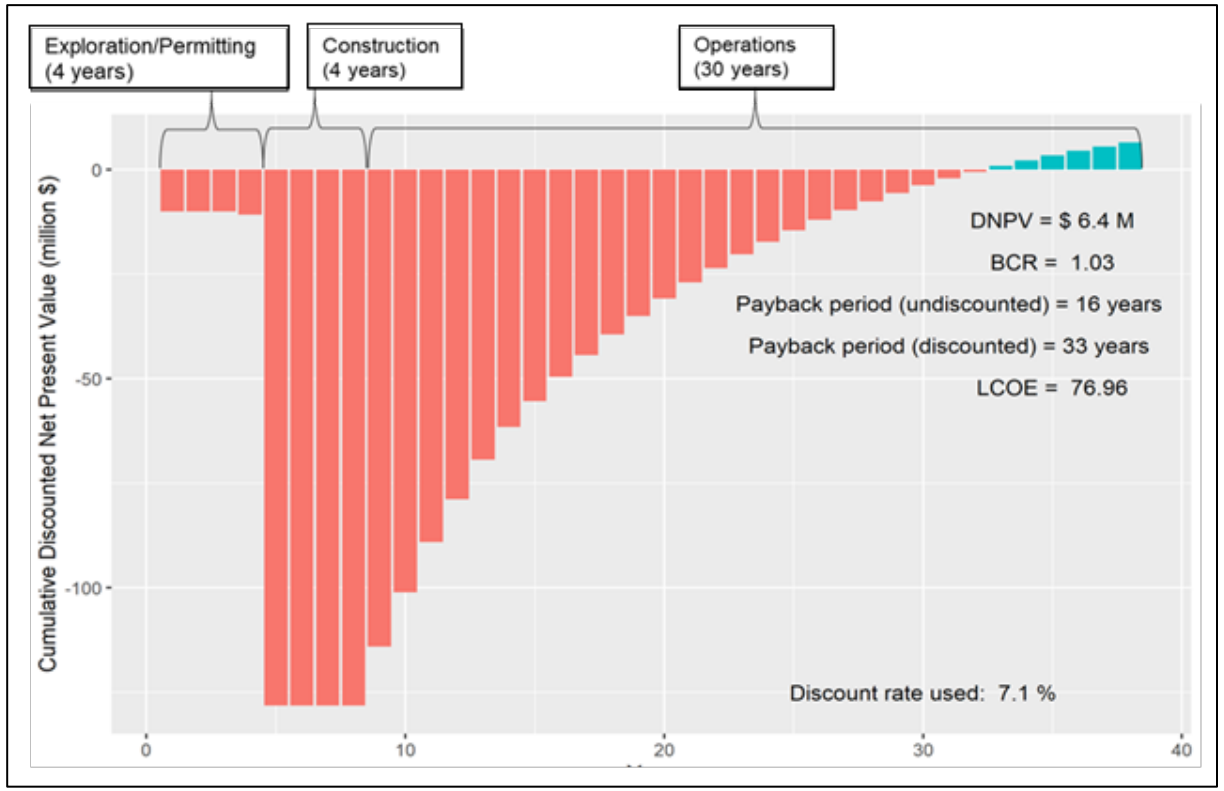
- Streamlined Permitting
- Government backed loans
- Production Tax Credits
- Property Tax Credits
- Investment Tax Credits

Technology Solutions

- Lithium extraction
- EGS

Create a site-specific techno-economic (TEA) model

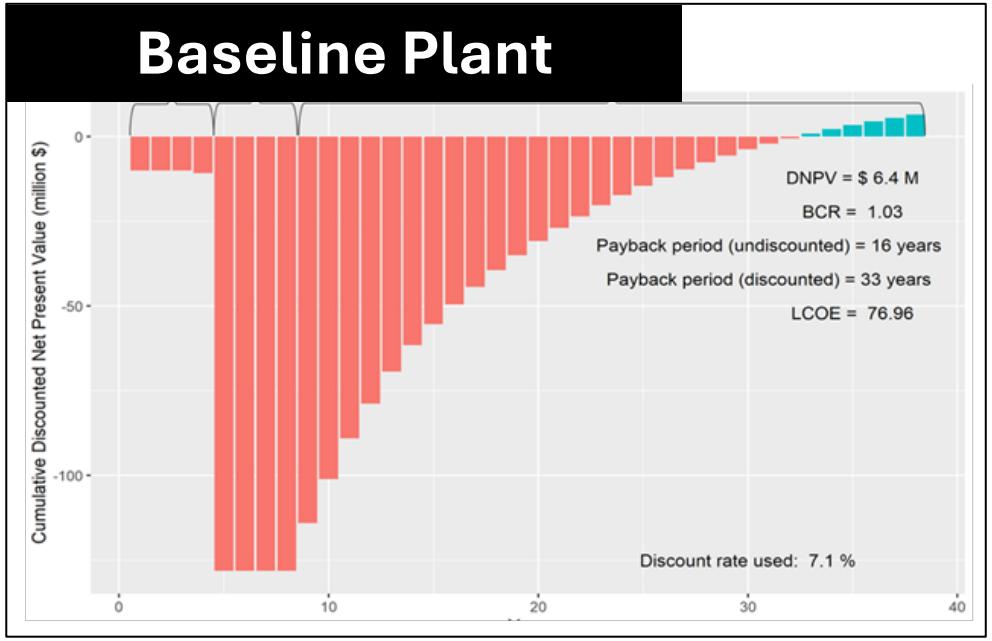
Work w/ industry to create a "baseline geothermal plant" like this Salton Sea one



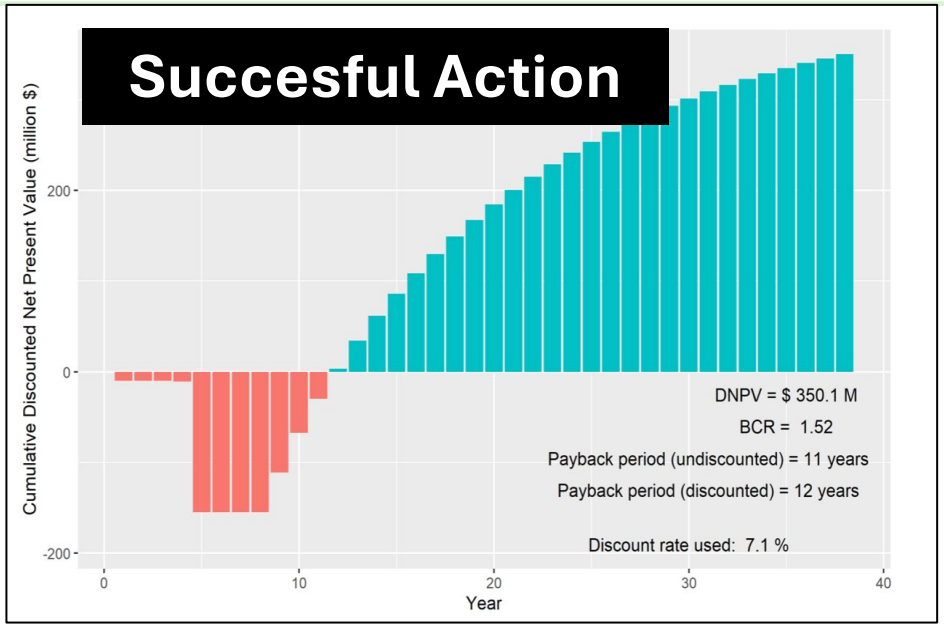
Parameter	Value
Geothermal Plant	
CAPX geothermal	$3,500/kW (171.5M for 49 MW plant)
OPEX geothermal	$3.25M/yr
Permit + habitat mitigation costs	$1,000,000
Plant lifetime	30 years
Plant size	49 MW
Capacity factor	330 days per year
Annual production loss	1%
Financial	
Discount rate	7.1% WACC for exploration and operation.
Power price	$80/MWh
Federal tax rate	21%
State tax rate	8.84%
Regulatory	
Construction time	4 years
Exploration time	4 years
Exploration cost	$10M
Investment tax credit	10%
Annual Property taxes	3.5M
Lithium	
CAPX lithium	$35M
OPEX lithium	$40M per year
Lithium harvest	8,350 tons per year
Wholesale lithium price	$13,000 per ton of lithium carbonate
CAPX = capital costs; OPEX = operations costs; WACC = weighted average cost of capital.	

Determine which solutions would lead to success

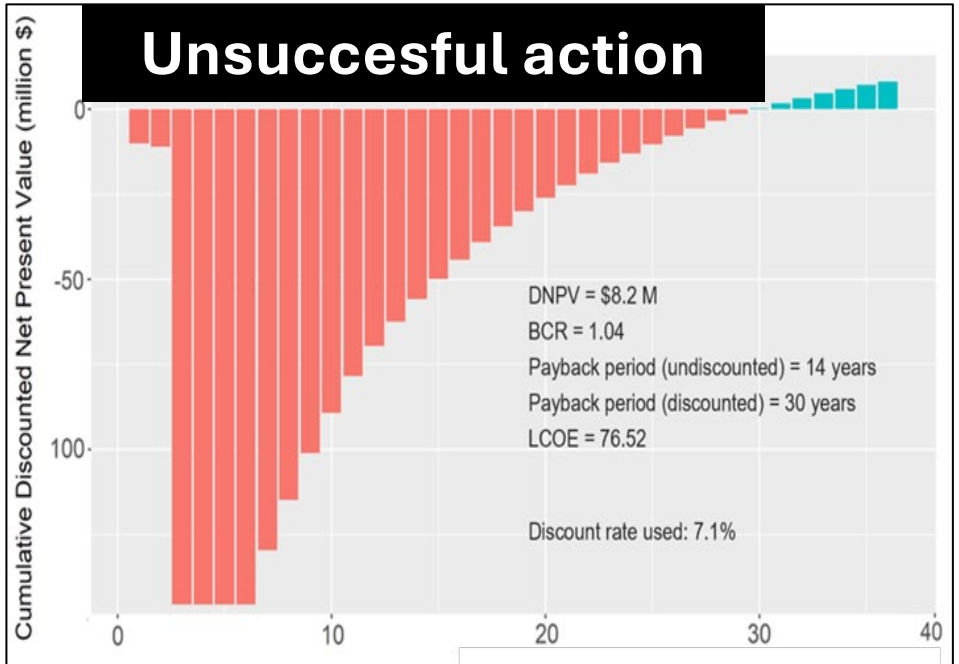
Baseline Plant



Succesful Action



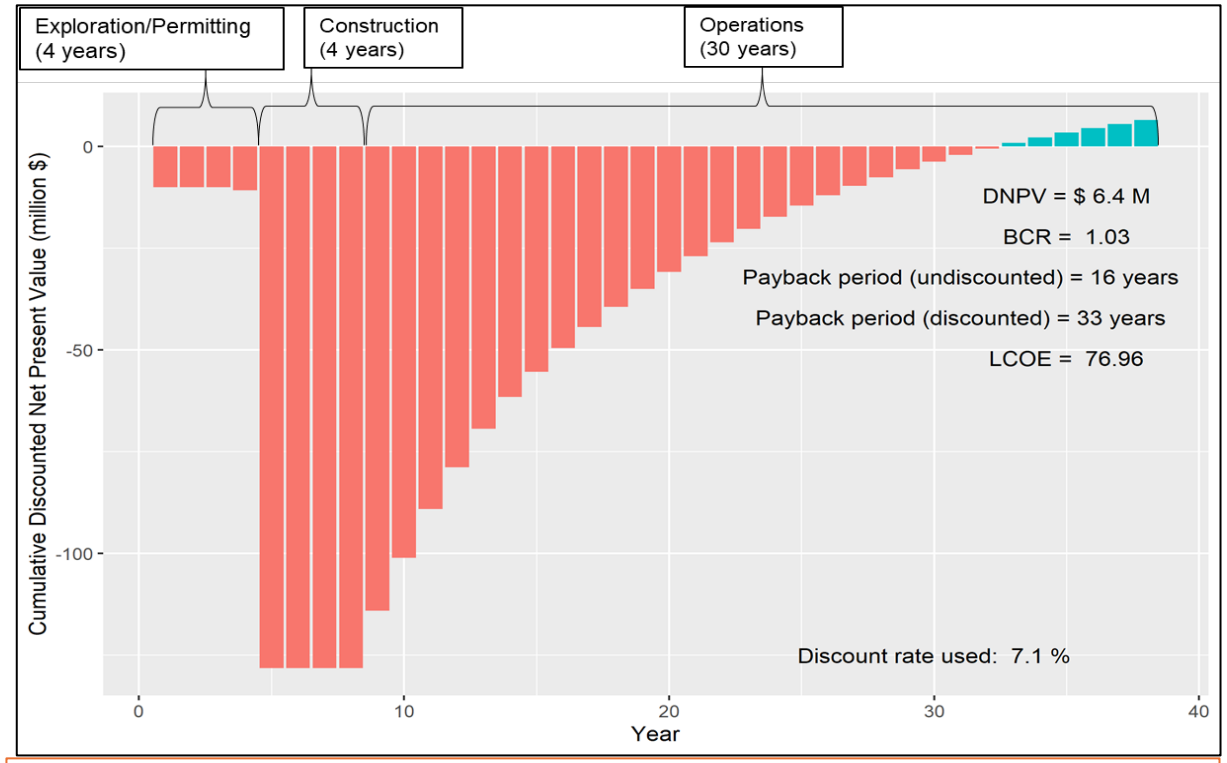
Unsuccesful action



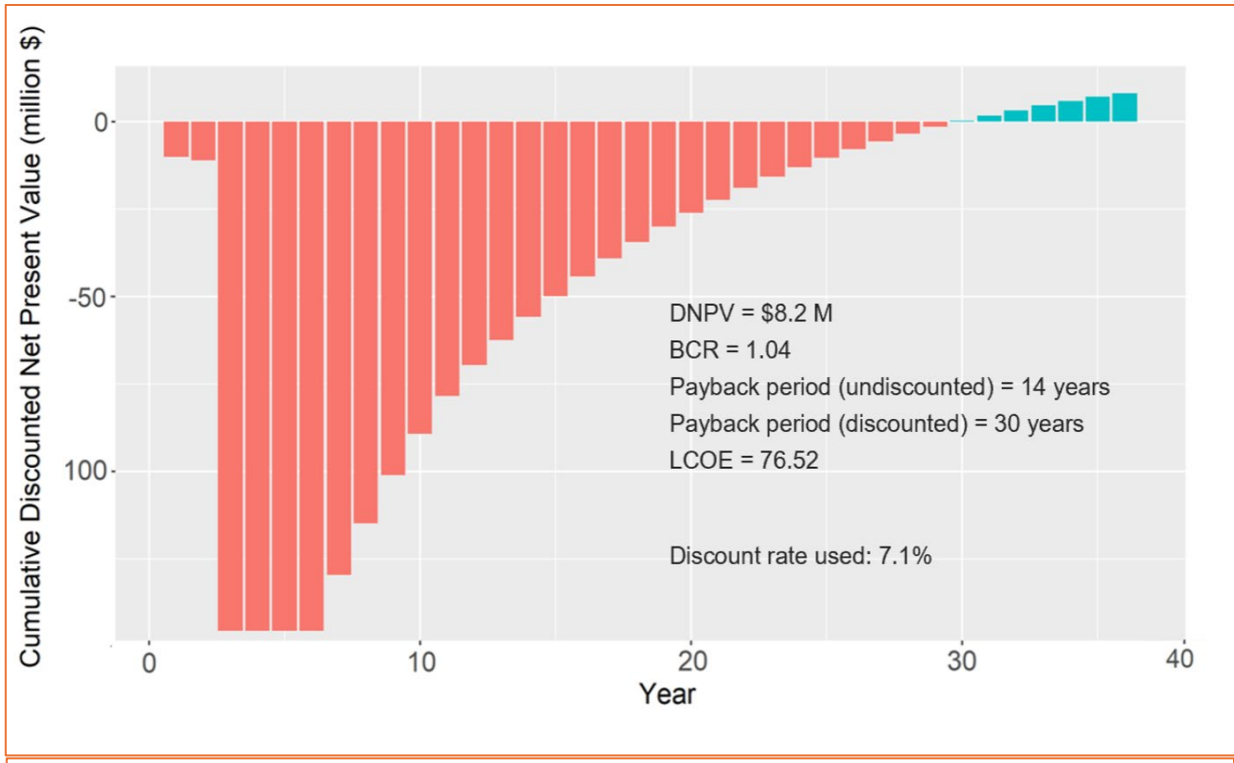
SECTION 3:
SALTON SEA RESULTS

Streamlining Permitting Times

Low financial benefits - but helps derisk projects



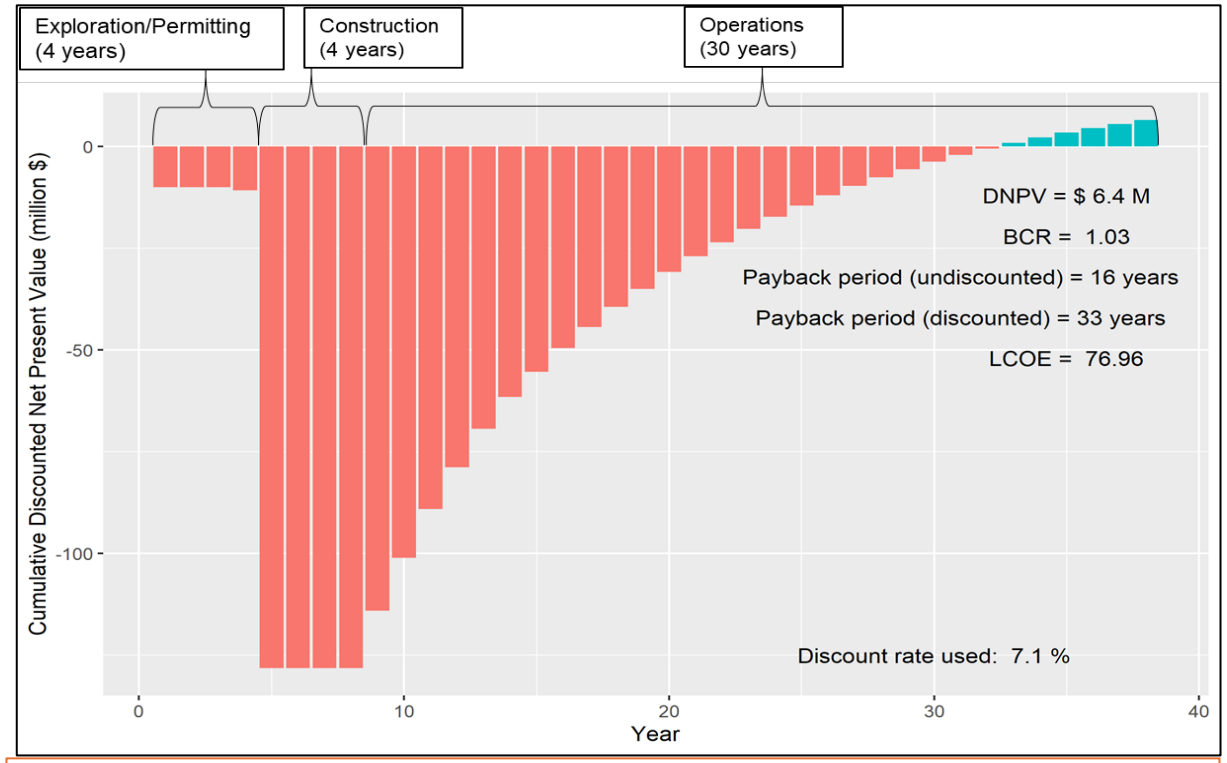
Baseline assumed 4 years of exploration + permitting times



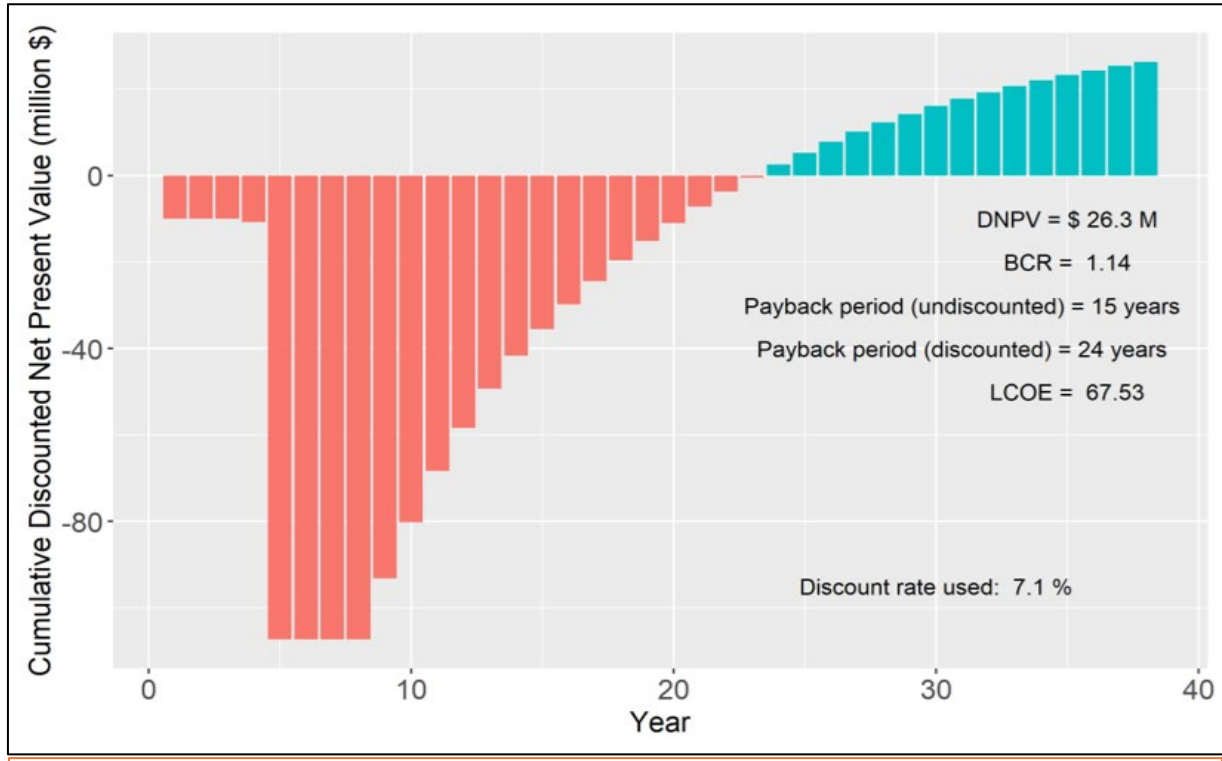
Cutting permitting times by two years has a small impact

Increase the Federal investment tax credit

Moderate benefits -- but not enough to overcome the financial barriers



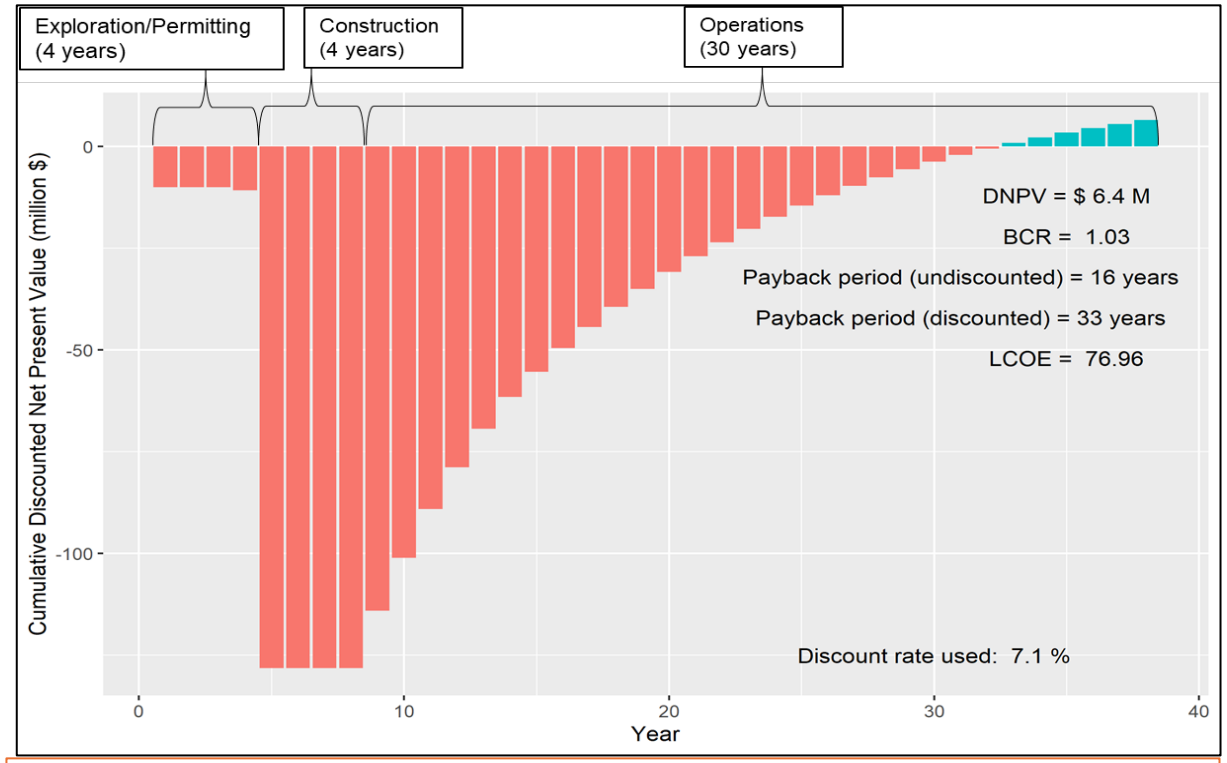
Baseline uses current 10% ITC



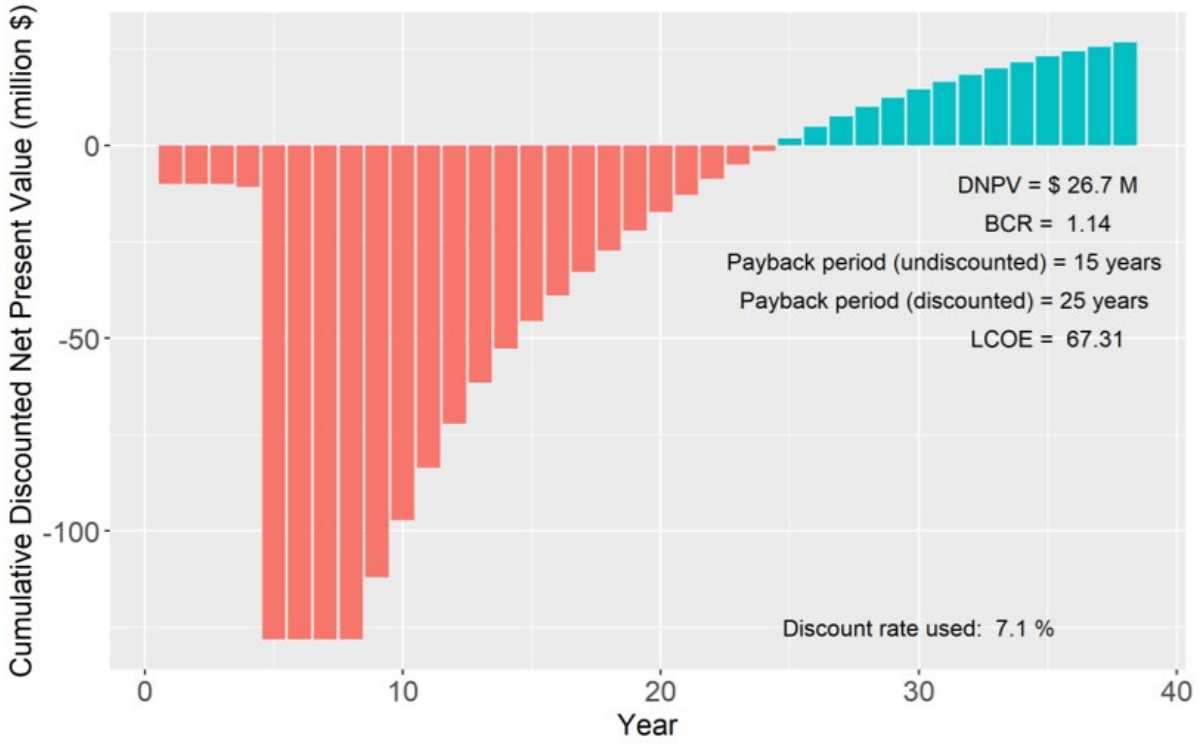
Using a 26% ITC like solar had

Grant a 10-year property tax waiver

Moderate benefits -- but not enough to overcome the financial barriers



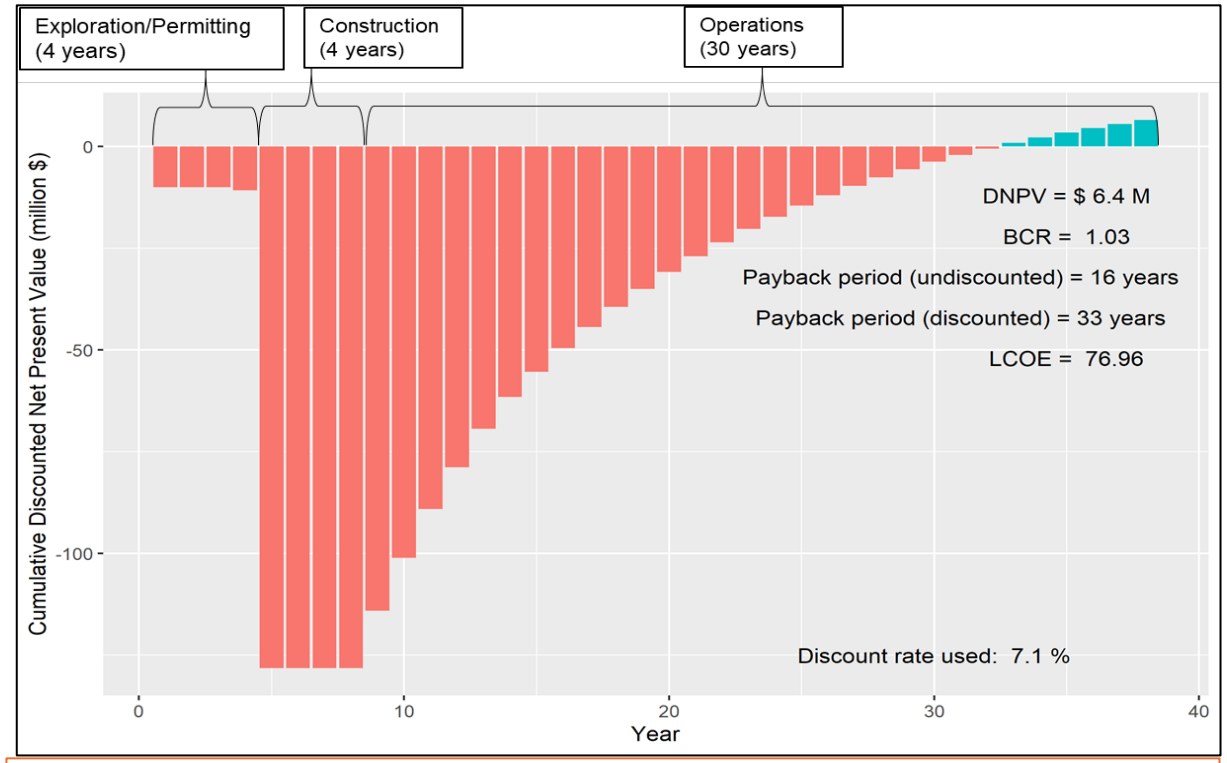
Baseline uses 2% during all production years



Waiving property taxes for the first 10-years of production

Grant a 10-year property tax waiver

Moderate benefits -- but not enough to overcome the financial barriers



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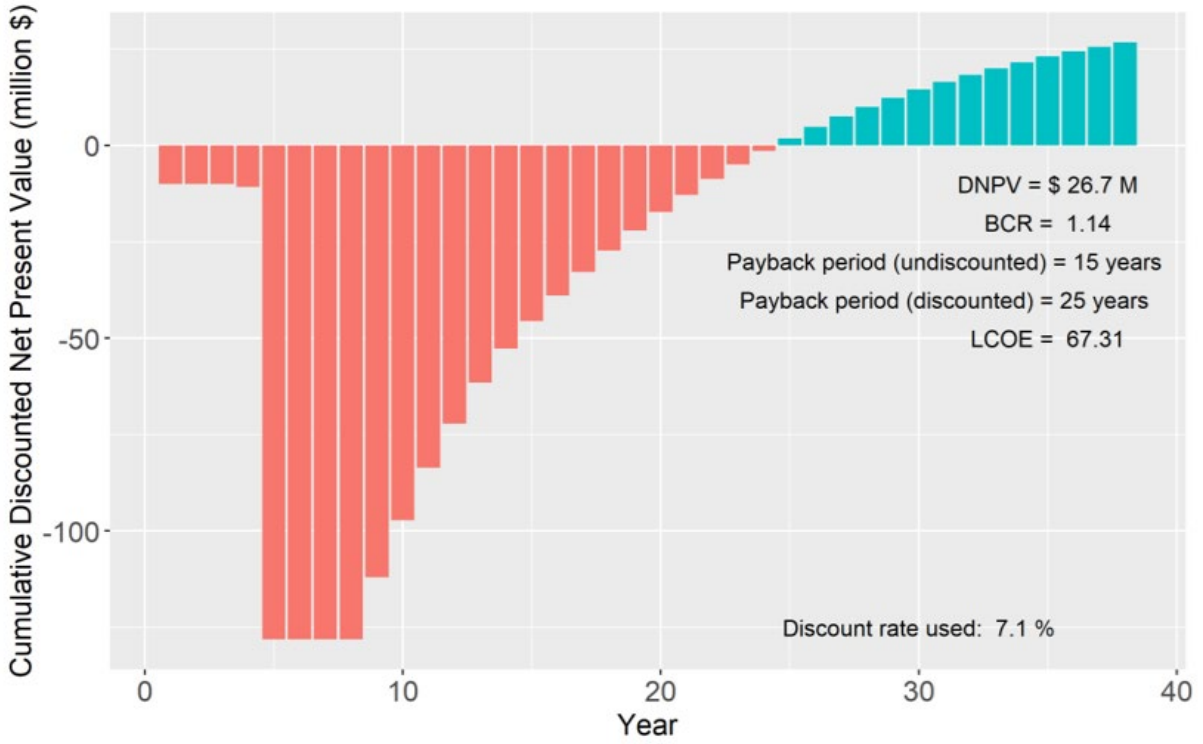
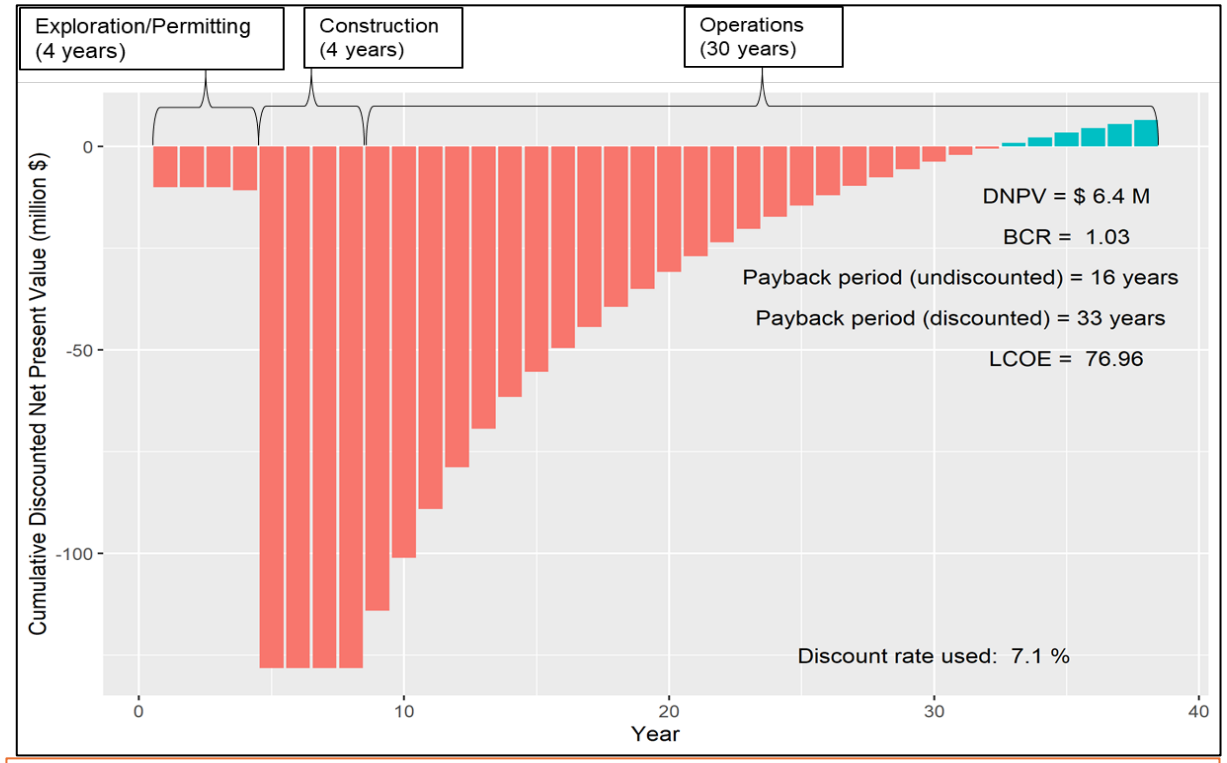


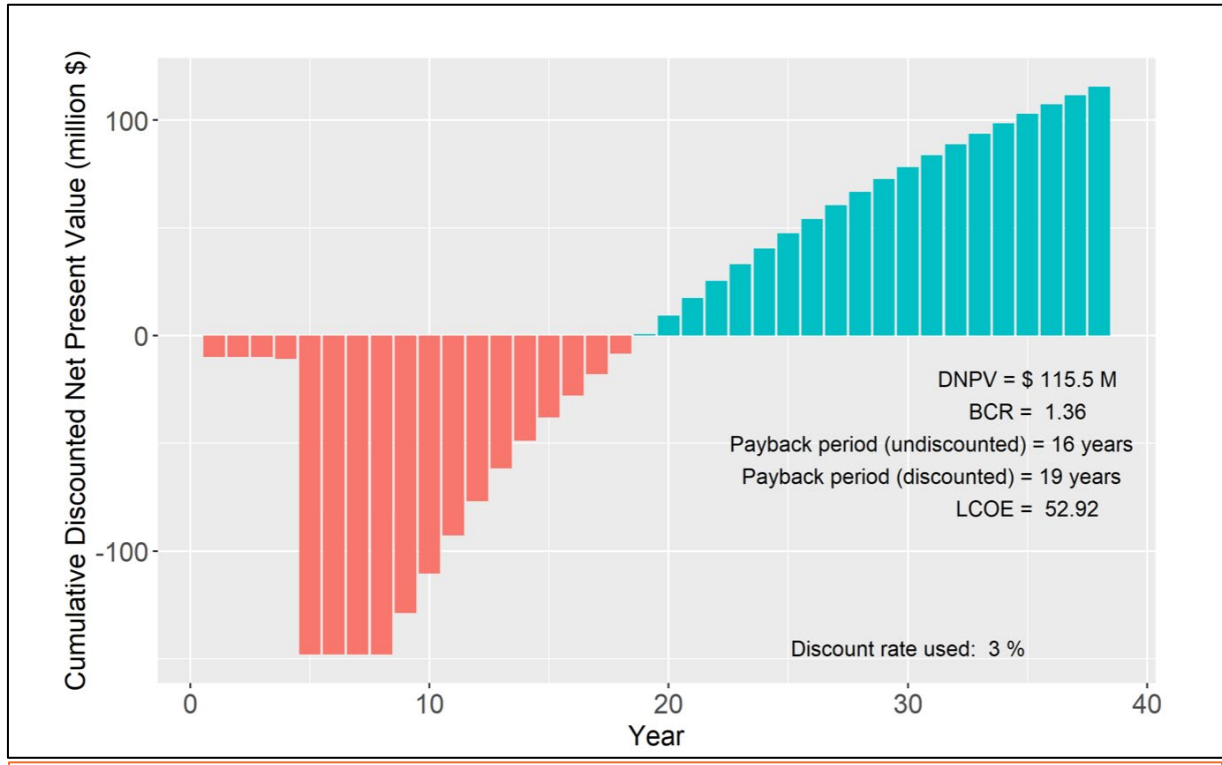
Waiving property taxes for the first 10-years of production

Use government-backed loans to lower discount rates

High benefits - but might need to explore adding more solutions



Baseline assumes a 7.1% discount rate

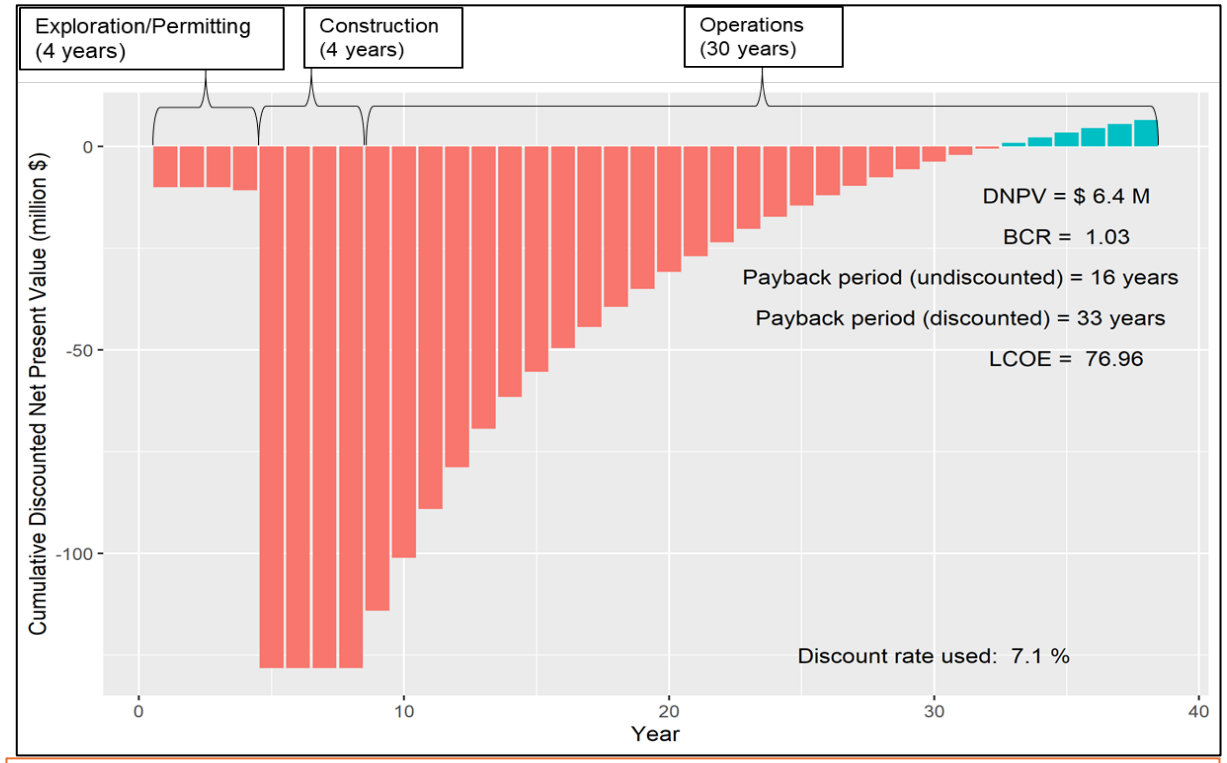


Results of a 3.1% discount rate via a gov't-backed loan

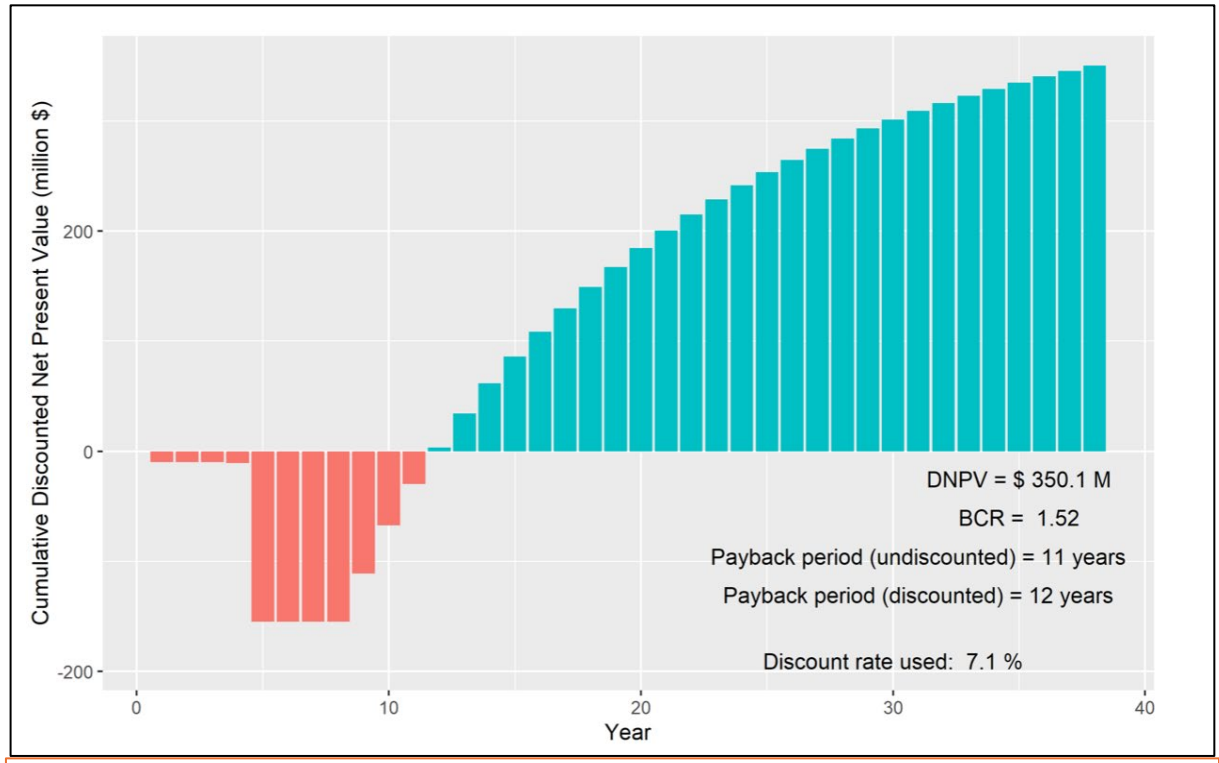
DOE Loan Office Requirements | Prior geothermal projects given federal loans

Adding a lithium plant

A gamechanger if the technology pans out -- but mixed levels of industry optomism



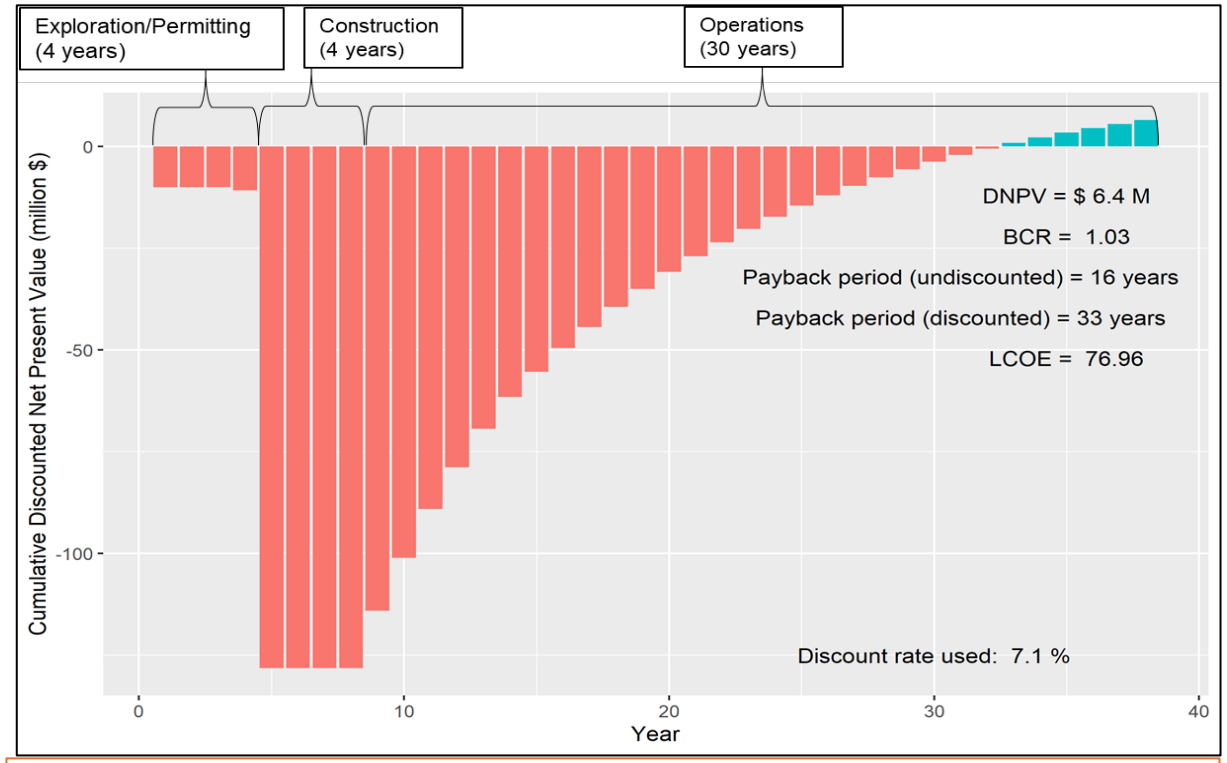
Baseline plant just produces power



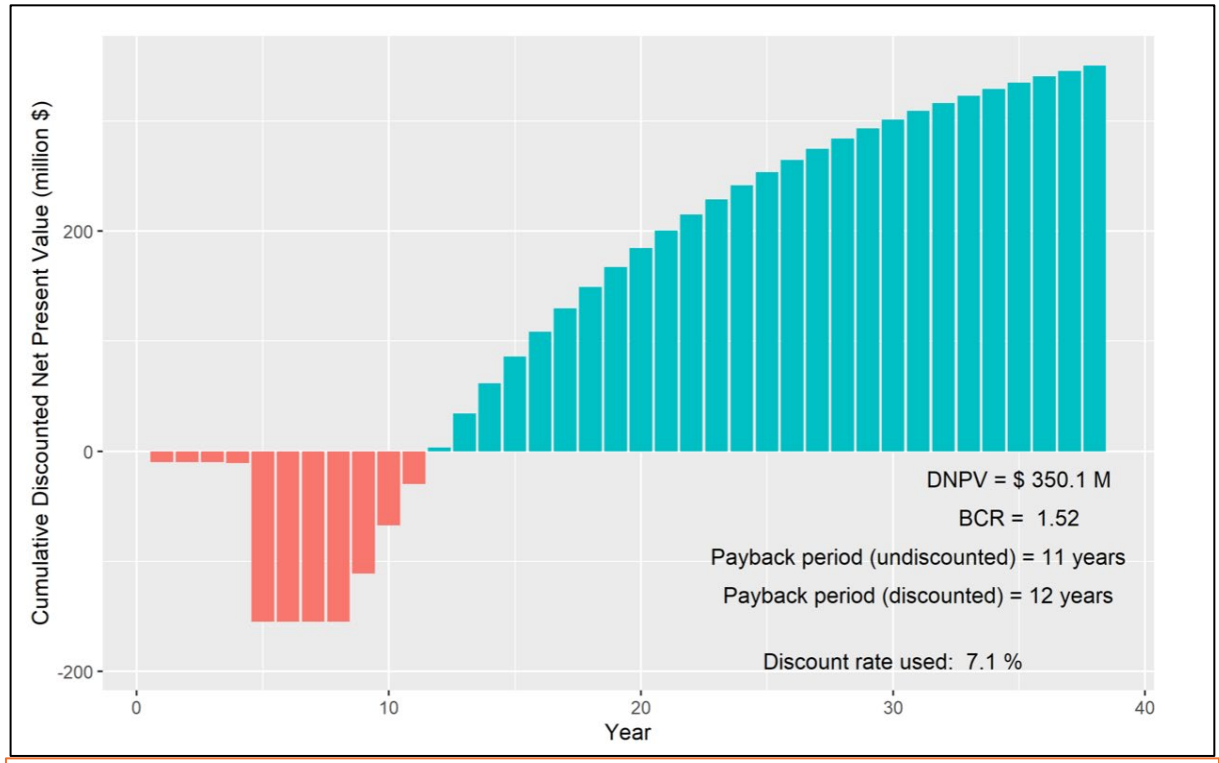
Adding a successful lithium plant

Adding a lithium plant

A gamechanger if the technology pans out -- but mixed levels of industry optomism



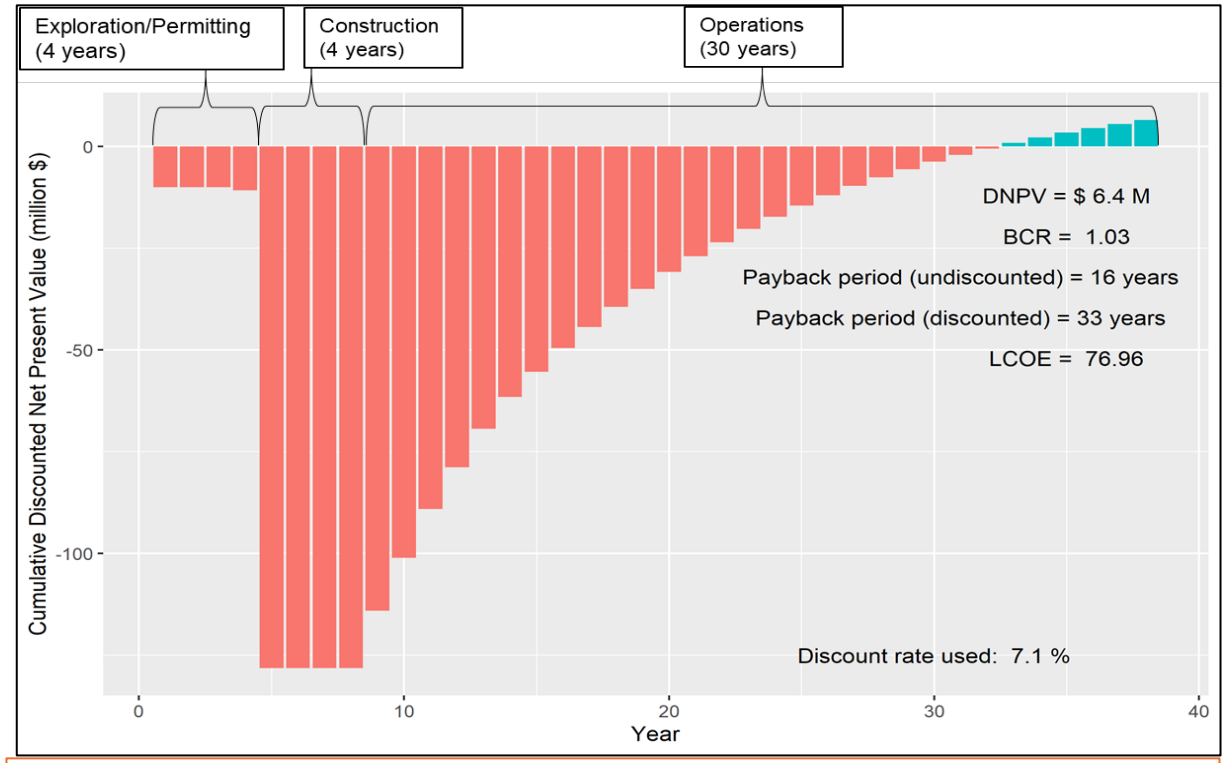
Baseline plant just produces power



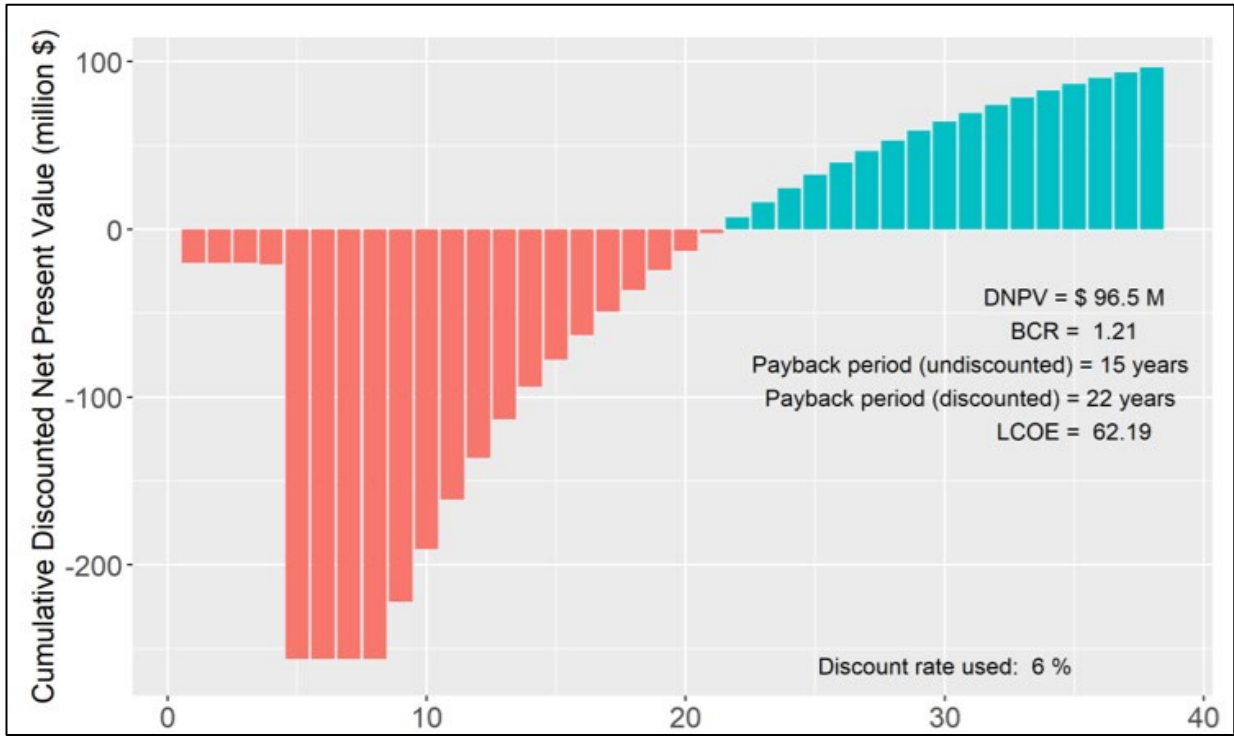
Adding a successful lithium plant

Enhanced Geothermal System (EGS)

A successful EGS would help - but might need to pair it w/ economic solutions



Baseline is a standard geothermal plant



Taking industry's EGS inputs from Newberry Crater, Oregon + applying them to a Salton Sea plant

SECTION 4:
IDEAL NEXT STEPS

Future steps for actionable site-specific solutions

STEP 1:	STEP 2:	STEP 3:	STEP 4:
Form a partnership w/ industry + regulators	**Identify the size of barriers + brainstorm solutions**	**Create a site-specific TEA model to evaluate proposed solutions**	**Evaluate if potential solutions can overcome financial barriers**

STEP 5::	**STEP 6::**	**STEP 6::**
Determin the optimal combination of benefits (single solutions aren't enough)	**Vet the results w/ industry + propose solutions to decision-makers**	**Evaluate site-specific actions for other geothermal areas**

CONCLUSIONS

#	Conclusions
1	Geothermal growth has been limited since the 1980's - even in prime areas like the Salton Sea
2	Financial barriers are the main issue
3	Some proposed solutions sound good, but may provide low benefits
4	There are several actionable economic solutions that could help!
5	Lithium extraction could be a gamechanger if the technology pans out
6	EGS could be very helpful if the technology pans out -- but still may need it pair EGS w/ other solutions for success
7	In the future, PNNL hopes to identify the ideal sets of solutions to overcome financial barriers + do other site-specific reviews (like Salton)

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Back-up slide: Discounted Net Present Value

Year	Cash Flow	Discount factor	Present Value (PV)	Cumulative PV
0	-1,000,000	1.0000	-1,000,000	-1,000,000
1	100,000	0.9259	92,593	-907,407
2	100,000	0.8573	85,734	-821,674
3	100,000	0.7938	79,383	-742,290
4	100,000	0.7350	73,503	-668,787
5	100,000	0.6806	68,058	-600,729
6	100,000	0.6302	63,017	-537,712
7	100,000	0.5835	58,349	-479,363
8	100,000	0.5403	54,027	-425,336
9	100,000	0.5002	50,025	-375,311
10	100,000	0.4632	46,319	-328,992

Assumptions	
Discount rate	8.00%
Investment cost	-1,000,000
Cash flow	100,000

$$\text{Discount Factor} = \frac{1}{(1+r)^n}$$

- r = discount rate (8% = 0.08)
- n = year

Year	Cash Flow	Discount factor	Present Value (PV)	Cumulative PV
0	-1,000,000	1.0000	-1,000,000	-1,000,000
1	100,000	0.9901	99,010	-900,990
2	100,000	0.9803	98,030	-802,960
3	100,000	0.9706	97,059	-705,901
4	100,000	0.9610	96,098	-609,803
5	100,000	0.9515	95,147	-514,657
6	100,000	0.9420	94,205	-420,452
7	100,000	0.9327	93,272	-327,181
8	100,000	0.9235	92,348	-234,832
9	100,000	0.9143	91,434	-143,398
10	100,000	0.9053	90,529	-52,870

Assumptions	
Discount rate	1.00%
Investment cost	-1,000,000
Cash flow	100,000